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Cannabidiol Product Dosing and Decision-Making in a National Survey of Individuals with Fibromyalgia

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Abstract

Many people with fibromyalgia use cannabidiol (CBD) products despite limited rigorous evidence of benefit. In the current study, we conducted a secondary analysis of a cross-sectional survey of N=878 people with fibromyalgia to investigate naturalistic decision making around CBD product choices, use patterns, and dosing. We subgrouped participants based on use of high-THC cannabis (HTC) in the past year (yes/no) as previous studies have shown that HTC use influences CBD use patterns. The study population was largely female (93.6%), white (91.5%) and 55.5 years old on average. Participants typically purchased CBD products online or at dispensaries, with purchasing driven by personal research (63%) rather than endorsement from medical professionals (16%). Overall, tinctures and topicals were the most common administration routes endorsed. However, participants in the past-year HTC group used inhalation routes far more frequently than those who did not (39.8% vs. 7.1%). Among participants using CBD tinctures or edibles, the average dose per session was 16mg and 24-27mg per day. However, approximately one-third of participants did not know what dose of CBD they used. Participants using both inhalation and non-inhalation administration routes reported greater symptom relief than those using non-inhalation routes alone. However, there was no consistent relationship between CBD dose and reported effects, possibly due to expectancy effects around CBD products or interindividual variability. Our granular investigation reveals variability of CBD product dosing practices for fibromyalgia, and how past-year HTC use influences CBD product use. Future clinical trials should investigate the potential benefits of low-dose (<50mg) botanical CBD products.

Introduction

Fibromyalgia (FM) is a common condition affecting 2-4% of the population that is characterized by widespread pain and a cluster of co-occurring symptoms, including fatigue, sleep disturbances, and cognitive dysfunction.[2, 18] Managing FM is challenging due to modest effects of approved fibromyalgia medications[17, 30] and limited access

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to non-pharmacological therapies.[4] As medical cannabis has become more available in the US,[7] many individuals with FM have reported using cannabis-based medicines for symptom management.[10, 25] Medical cannabis products often contain high concentrations of THC (Δ-9-tetrahydrocannabinol),[16] and thus have potential for abuse liability and negative side effects (e.g., cognitive dysfunction)[44] in addition to therapeutic value for pain and sleep.[51] However, since 2018 there has been increased attention to cannabidiol (CBD), a non-intoxicating cannabinoid which became widely available and marketed following the removal of hemp-derived CBD products (containing <0.3% THC) from the Controlled Substances Act.[12, 19, 33] As with medical cannabis products, CBD products come in many forms, e.g., edibles, oils/tinctures, lotions, and inhalable products (concentrates, flower).

With changing availability of CBD and medical cannabis products, some studies have investigated subgroups of individuals with different use patterns, such as solely using CBD-dominant products vs. using CBD products in conjunction with THC-dominant products.[9, 43] For example, Vilches et al showed that individuals in this latter category used more routes of administration (including smoking/vaping), were more likely to use CBD products for medical ailments, and had lower educational attainment.[43] Similarly, in a longitudinal cohort of young people using cannabis, Fedorova et al showed less use of inhalation forms among people using CBD-dominant products as well as more use for medical reasons.[23] Several other studies have examined trends of CBD product use and dosing (e.g., showing that use of cannabis increases odds of CBD product use)[27] but typically did not compare those with and without concurrent use of THC-dominant cannabis products.[20, 36, 50]

However, these trends have not been examined among people with FM, which is relevant given differences in THC and CBD effects for FM symptoms. THC analogs (e.g., nabilone) show some benefits for pain and sleep among people with FM.[41, 46] In contrast, the only clinical trial conducted to-date using CBD in FM found that while a single inhalation of CBD-dominant flower showed no statistically significant effect on pain, an approximately 1:1 ratio of CBD:THC did improve pain compared to placebo.[42] In naturalistic settings, however, we recently showed that 32% of people with FM in the US use CBD products to manage symptoms[5] and commonly substitute CBD products for opioids and pain medications.[6] Many participants also reported past-year high-THC cannabis use (defined as containing little or no CBD, hereafter “HTC”), so elucidating differences between individuals using CBD or CBD in combination with HTC use may inform appropriate clinical care of individuals with FM using these products.

As such, we sought to characterize CBD product use patterns among individuals with FM from our recent large online survey, stratifying by past-year HTC use. Our goal was to describe how people with FM were using CBD products for symptom management, including decisions around product purchasing, routes of administration, and dosing. We explored relationships between administration and dosing patterns as well as how these related to perceived symptom changes and health. We hypothesized that 1) higher doses and 2) combined inhalation and non-inhalation routes would be associated with more symptom relief as 1) higher CBD doses (100-600mg) have been shown to be effective in clinical trials

of pain-related symptoms (e.g., anxiety[31, 35]), and 2) that inhalation often allows for easier titration of effect than other routes.[34]

Methods

As previously described, we collaboratively designed the survey, drawing on commonly asked questions about CBD in the FM community (LM) as well as our previous research on cannabis use for chronic pain (KFB, DW).[8, 10] The National Fibromyalgia Association led recruitment efforts in April and May of 2020 by sending an anonymized survey link (Qualtrics, Provo, UT) to members through a listserv and promoting the survey via press releases and social media. The Institutional Review Board at the University of Michigan approved this study (HUM00170424). Respondents freely consented to participate, could drop out at any time, and received no compensation for participating.

We conducted a secondary analysis of data collected on CBD product use among participants with FM. The study population was the subset of individuals reporting current CBD product use (n = 878) from our original survey (n = 2,701).[5] Participants completed questions on demographic information including sex, age, race/ethnicity, household income, education level, employment status, and location. As described previously, we classified locations by whether they had laws in place legalizing medical or recreational cannabis. Participants also selected all of their physician-diagnosed pain conditions (including FM), with an option for free text entry for unlisted conditions. As current HTC use is known to affect CBD product use patterns,[20] we also asked participants to describe their past-year HTC use (defined as containing little or no CBD), with options of: *no use, medical only, recreational only,* or *a combination of medical and recreational.* Recreational only use was minimal (<5%), so we created two subgroup categories: no past year cannabis use (n = 410, henceforth “no HTC group”) and past year HTC use (n = 468, henceforth “HTC group”).

FM and other chronic pain symptoms

As previously described, participants completed the 2011 FM Survey Criteria and the Complex Medical Symptom Inventory (CMSI). The 2011 FM Survey criteria measures widespreadness of pain (0-19 body sites) and severity of co-morbid symptoms, such as sleep issues and trouble thinking.[54] This measure is scored continuously with values ranging from 0-31. The CMSI measures functional somatic burden and is scored from 0-41, with higher scores indicating more burden from symptoms associated with chronic overlapping pain conditions.[47–49, 53]

CBD product dosing regimen

We asked whether participants had a stable use routine for CBD products. Those with a stable routine then indicated how long it had taken for them to develop that use routine.

Decision making around CBD products

Participants indicated where they purchased their cannabis products, selecting from: *online vendor, medical cannabis dispensary, adult use cannabis dispensary, brick and mortar retailer (e.g., supermarket, gas station, etc…), doctor’s office, a friend or acquaintance, I grow my*

own, and *other*. They also indicated how they selected CBD products, with options of: *Personal research, Advice from employee at place of purchase, Customer reviews, Potency, Brand recognition, Independent, third-party testing, Endorsement by a friend, Endorsement from a medical professional, Advertising, or Other.*

Frequency of CBD product use

Participants indicated how frequently they used CBD products, both in days per week and times per day.

Administration and dosing

Participants selected their most frequently used CBD product from a list that included: *CBD isolate (solely CBD), full spectrum CBD with less than 0.3% THC,* and *CBD with more than 0.3% THC.* Those who did not indicate a preference were coded as "no preference".

Participants selected all the ways in which they administered CBD products from a list that included: *smoking CBD-dominant flower, vaporizing CBD-dominant flower, vaporizing concentrates, eating, topical applications, tinctures,* and *other.* Examples of each administration route were provided in the survey - e.g., edibles such as gummies, cookies, and candies). Participant administration route use patterns were classified as inhalation only, non-inhalation only, and combined non-inhalation+inhalation. Participants then specified how many times per week and day they used each administration route, as well as their typical dose per session if known. We assessed dose in puffs for inhalation routes (smoking, vaporizing) or milligrams (tinctures, edibles). Dose ranges for puffs per session were 1-10 and 10+ puffs, and dose ranges for oral milligrams per session were 1-50mg and >50 milligrams per session. Topical and "other" administration routes did not have session dosing options.

We then calculated overall oral daily dose in milligrams for individuals using either tinctures, edibles, or both tinctures and edibles by multiplying the number of doses per day by the milligrams per session (e.g., 5 mg of CBD edible three times per day = 15 mg/day). Daily doses were divided into three categories: 1-25mg, 26-50mg, and >50 mg/day. Calculating mg per day doses for topicals, concentrates, vaporizing, smoking, and other administration routes was not possible given the uncertainty associated with converting the daily use patterns into mg per day.

Perceptions of CBD product effectiveness

We assessed symptom changes in the following subgroups: 1) past year vs. no past year HTC use; 2) inhalation administration routes only, non-inhalation administration routes only, and combined non-inhalation+inhalation administration routes, and 3) among participants with complete dosing information (1-25mg, 26-50mg, >50 mg/day). Symptoms changes were measured as previously described.[5] Briefly, participants selected symptoms for which they used CBD products from a list that included pain, insomnia or sleep problems, anxiety, fatigue, depression, memory or clarity of thought, and other. We chose these symptoms as they frequently co-occur with FM and other chronic pain conditions.[39, 52] For each symptom selected, participants rated how their symptom had changed since using CBD products using

a 7-point Likert scale adopted from the Patient Global Impression of Change, ranging from "very much worse" to "very much improved". Participants also rated how their overall health had changed since using CBD products using the same 7-point Likert scale.

Statistical analysis

We first characterized the study population using descriptive statistics. We sub-grouped participants by their past year use of HTC. We assessed differences in proportions for categorical variables (e.g., income level, relationship status) using Pearson's Chi-square (X^2) test, and reported results as frequency (percent, %). We assessed between-group differences in continuous variables (e.g., age, differences in symptom changes) using t-tests for two groups (e.g., by past year cannabis use) and analysis of variance (ANOVA) for three or more groups (e.g., by dosing group). We controlled for multiple testing of symptoms and overall health change using the Benjamini-Hochberg procedure.[3] We conducted post-hoc pairwise testing using Tukey's test for ANOVA results that remained statistically significant after the Benjamini-Hochberg procedure. We report normally distributed continuous variables as mean ± standard deviation, otherwise as median ± interquartile range (IQR). All analyses were conducted in STATA/SE 14.2 (StataCorp, College Station, TX).

Results

Demographics and clinical characteristics

Respondents (N = 878) were predominantly white, older (55.5 ± 12.2 years), and 45.7% had a college degree or more education. Respondents lived in all US states except Wyoming and Vermont, as well as Canada (4.8%) and other English-speaking countries (1.7%). The highest proportion of respondents came from California (12.9%), Michigan (6.0%), Florida (4.5%), Pennsylvania (4.2%), and Texas (4.0%). Participants in the past year HTC subgroup were significantly younger (mean difference = 2.7 years, 95% CI [1.2 – 4.4], p = 0.0004), lived in places with access to legal cannabis (p < 0.001), and had a higher FM score (mean difference = 1.3, 95% CI [0.6 – 2.1], p < 0.003) and higher CMSI score (mean difference = 1.6, 0.5 – 2.6).

CBD product purchasing and rationale

The most common venue for CBD product purchasing was online, followed by medical cannabis dispensaries, brick and mortar retailers, and adult use cannabis dispensaries (Table 2). However, more participants in the HTC group purchased from cannabis medical or adult use dispensaries than those in the no HTC group (p's < 0.001), while more participants in the no HTC group purchased online or from brick-and-mortar retailers (p's < 0.001). Overall, most participants selected CBD products based on their personal research, with only 16.4% reporting endorsement from a medical professional. A higher percentage of those in the HTC group endorsed advice from an employee at the place of purchase than those in the no HTC group (p < 0.001).

CBD product administration and use patterns

Overall, the most common administration routes were tinctures, topicals, and edibles (Table 3). However, a higher proportion of participants in the HTC group used inhalation

administration routes (smoking, vaporizing CBD flower, vaporizing CBD concentrates) and edibles, as well as using a greater number of administration routes overall (all p's < 0.001). Those in the HTC group also combined inhalation and non-inhalation routes and used CBD products with >0.3% THC more frequently than those in the no HTC group. While there were no differences in days used per week, there was a significant difference in number of daily uses, with those in the HTC group using CBD products more frequently. Two-thirds of participants had a stable dosing pattern of CBD products. Of these, 45% of participants developed a stable dosing pattern within 1 month and 44% within 1-6 months.

CBD product dosing

Table 4 displays granular detail of dosing patterns among participants, and supplementary Table 1 shows this granular detail between subgroups. On average, participants typically used products of various administration routes between 4 and 6 times per week. Inhalation administration routes were typically employed 2-3 times per day, while other administration routes were used 1-2 times per day. Notably, nearly 35% of participants using tinctures and 34% of those using edibles did not know their dose in milligrams, while 14% and 12% reported using >50mg per session (the maximum dose that participants could enter).

Relationships between dosing categories, administration routes, and changes in symptoms

After Benjamini-Hochberg adjustment, there were no statistically significant differences in changes in symptoms or overall health between participants in the HTC use subgroups, nor were there statistically significant differences between dosing groups and any symptom domain. However, participants who used non-inhalation+inhalation administration routes reported significantly improved overall health (mean difference = 0.40, 95% CI [0.25 – 0.56], p < 0.001), pain (mean difference = 0.25, 95% CI [0.11 – 0.39], p < 0.001), memory (mean difference = 0.68, 95% CI [0.3 –1.06], p < 0.001), sleep (mean difference = 0.35, 95% CI [0.14 – 0.56], p = 0.001), anxiety (mean difference = 0.25, 95% CI [0.05 – 0.46], p = 0.014), and depression (mean difference = 0.23, 95% CI [0.05 – 0.67], p = 0.02) compared to those who used non-inhalation administration routes after Benjamini-Hochberg adjustment. [Note, the inhalation group sample size was too small to include as a comparator.]

Discussion

This study is among the first attempts to describe how people with FM choose and use CBD products and provides novel, granular detail on use and impacts on symptoms of both routes of administration and dosing.

We show that past year HTC use is associated with younger age, greater use of inhalation administration routes and CBD products with >0.3% THC, and higher clinical burden as measured via the FM score and CMSI. These group-level characteristics are consistent with findings from other studies comparing people using CBD products alone vs. CBD products and HTC.[43] They also align with characteristics of older medical cannabis patients (>50 years). Indeed, a recent study of medical cannabis patients from New York showed

similar preferences: products with higher CBD : THC ratios and more use of tinctures.[32] Respondents using HTC in our study also had distinct purchasing behaviors for buying CBD products, more frequently purchasing at cannabis dispensaries rather than online – a behavior that may actually be protective as dispensary products typically have state oversight while online vendors are not subject to quality control standards.[19] Participants typically selected products based on personal research or advice from an employee at the place of purchase, with very few purchasing products at a doctor's office or based on the advice of a medical professional. This behavior emphasizes how separate CBD product use is from mainstream medicine, leaving consumers subject to the widespread and often unsubstantiated hype around CBD products[1] or budtenders/retailers who typically have little or no medical training.[29]

With regards to CBD product use patterns and dosing, participants in the HTC group used CBD products more times per day but not more days per week. This likely reflects the higher use of inhalation administration routes (which were used more frequently per day in our study) which have faster effect onset but do not last as long as tinctures or edibles.[34] Two-thirds of participants reportedly developed a stable dosing pattern, with most (79%) doing so within 6 months. This suggests that while many people who continue using CBD products eventually figure out a regimen that works for them, targeted guidance from a medical professional may be helpful for optimizing CBD product use. While there were few significant differences in dosing between subgroups, the overall picture shown through the granularity of our dosing data provide a unique snapshot into CBD product use for FM: predominance of tinctures and topicals used 1-2 times per day, generally at doses (for oral products) of around 25 mg/day. However, approximately one-third of participants did not know what dose they were taking, possibly a reflection of inaccurate CBD product labeling practices (which may not include potency)[11] and/or lack of knowledge about the products they were taking. The latter point mirrors a recent Canadian study in which rheumatology patients demonstrated fairly limited knowledge about their cannabinoid products, with 20 of 34 participants using oils and capsules reporting their daily dose or cannabinoid content.[24]

When examining how patterns of use influenced reported outcomes, routes of administration did appear to influence FM symptoms and overall health, with participants using mixed non-inhalation+inhalation routes reporting greater improvement than those using non-inhalation routes alone. This result may be due to more effective dose-layering[9]: i.e., improved ability to titrate with fast-acting effects of inhalable products in addition to the longer-acting effects of edibles, topicals, or oils/tinctures. It is also possible that since most participants in the mixed non-inhalation+inhalation group also used HTC in the past year, their use of THC-containing products resulted in greater positive impact given the synergistic analgesic effects combined THC and CBD as well as mitigation of THC-related side effects with co-administration of CBD.[15, 34, 38] However, we found no relationship between dosing in mg/day and perceived effects on symptoms. This was surprising as we expected that higher doses might lead to more improvement – especially for symptoms (e.g., anxiety, sleep[14]) where higher doses (100-400mg) have been shown promise in small clinical trials.[21, 35, 55] This failure to see differential effects based on specific dose may be due to several factors. First, CBD products remain poorly regulated, with many products containing quantities of CBD that do not match the label, which could skew dosing estimates.[11, 28] Second,

CBD products carry strong expectancy effects due to the widespread popularity of these products[33] and aggressive marketing by companies promoting CBD's medical benefits,[1] which could lead to a strong placebo response regardless of dose. Third, people with FM often have generalized sensory hypersensitivity,[18] which may render lower doses more effective than they might be in a different population. Fourth, as previously described,[5] participants used CBD product for numerous different symptoms, and it is possible that dosing for different primary symptoms (e.g., pain, anxiety, and sleep) may result in different dosing patterns.

However, regardless of reasons why this may have occurred, the doses and associated patient-reported outcomes them are consistent with other observational studies that use more naturalistic dosing regimens. For example, Shannon et al conducted a large case series (n = 72) with CBD doses ranging from 25-75mg and reported no differences in sleep or anxiety outcomes based on dose.[40] Similarly, Capano et al conducted a prospective cohort study among people with chronic pain using opioids and showed that 30mg of CBD extract per day significantly improved pain and sleep.[13] These results highlight the need for appropriate dose-ranging CBD studies to better understand the effects of lower dose CBD for FM-related symptoms.

Clinical Implications

Use of CBD products is very common, with prevalence of use estimates ranging from 14-26% of Americans,[12, 27] and even higher among people with arthritis and FM.[5, 26] As shown by our results, naturalistic dosing paradigms contrast sharply with the limited clinical trial data on CBD in chronic pain and may be useful for guiding future rigorous studies with CBD. The lack of any relationship between dose and effects on symptoms suggests that interindividual variation may contribute to CBD product effects on symptoms and that the placebo effect may be influencing perceived symptom relief. The fact that many people did not choose CBD products based on the endorsement of a healthcare professional and did not know what doses they were taking highlights the importance of improved CBD-related education for healthcare workers as well as the need to advocate for better standardization of CBD products (e.g., improved labeling practices, enforced safety standards). This latter point is of special importance given that many participants purchased products online, which are largely unregulated and have potential safety issues, including: 1) poor congruence between claimed and actual quantities of CBD in products[11, 28]; 2) adulteration with synthetic cannabinoids[28]; 3) contamination with pesticides and heavy metals.[22, 37, 45]

Limitations

Our study has several limitations. First, subgrouping as a binary of past year HTC use does not capture differences in use intention (e.g., medical vs. recreational). Second, our cross-sectional design renders our results on CBD product effectiveness subject to recall bias. Third, the use of multiple administration routes other than tinctures and edibles resulted in only 23% of participants having complete dosing information, rendering it possible that these results do not truly represent an accurate dose response. Similarly, we do not have an estimate of dose for THC-containing products, which may influence the reported effects on symptom relief. Fourth, THC and CBD may have synergistic effects and many

participants used products containing both compounds in addition to minor cannabinoids and terpenes, so it is possible that our results are partially due to THC or these other components. Fifth, our categorizations of non-inhalation and inhalation do not fully capture the huge breadth of formulations and pharmacokinetics/pharmacodynamics of available CBD products, especially topicals which may act locally or systemically depending on whether they contain components that facilitate transdermal absorption. Sixth, our study population was a largely female, older, well-educated, White, convenience sample of participants who lived in the US, so our results may not generalize to other groups.

Conclusions

Our results show the great variability in CBD product dosing among people with FM. We show that past year HTC use may help differentiate between subgroups of CBD product use, with those using HTC fitting more in the category of medical cannabis patients (using more inhalation administration routes, buying from dispensaries) while those who do not make up a category of CBD product use (purchasing online, more use of topicals, tinctures, and edibles). Around one-third of participants did not know what CBD dose they were taking, highlighting the need for standardization around CBD product labeling. Use of mixed non-inhalation+inhalation administration resulted in the greatest reported improvement in symptoms and overall health. Given CBD's popularity and the lack of rigorous dosing studies, these results are timely as they can help guide healthcare professionals to ask appropriate questions about CBD product use, including dose and routes of administration. Our deep characterization of CBD product dosing shows that the majority of people use doses of ≤50mg of a given product, which provides a useful guide for future dose-ranging and efficacy studies of botanical CBD products.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosures:

Dr. Boehnke sits on a data safety and monitoring board for an ongoing clinical trial with Vireo Health (unpaid). Dr. Gagnier consults for Bartimus Frickleton Robertson Rader P.C., and for the Law Office of Robert J. Krakow, P.C., on topics unrelated to the content of this manuscript. Dr. Williams is a consultant to Swing Therapeutics Inc. and to Community Health Focus Inc. Ms. Matallana founded the National Fibromyalgia Association and is the CEO of Community Health Focus Inc. The National Fibromyalgia Association provided funding support for recruitment efforts. KFB's effort on this publication was partially supported by the National Institute on Drug Abuse of the National Institutes of Health under Award Number K01DA049219 (KFB). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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Highlights:

- People with fibromyalgia often purchase cannabidiol (CBD) without physician advice.
- Past year high-THC cannabis use was associated with use of inhalable CBD products.
- The average daily cannabidiol dose used (edibles or tinctures) used 24-27mg.
- There was no relationship between CBD dose and perceived symptom relief.
- Combined use patterns were associated with greatest symptom relief.

Perspective:

This article shows that past-year HTC use strongly influences how people with fibromyalgia choose and use CBD products. Participants typically used <50mg/day of CBD, and there was no relationship between higher CBD dose and reported therapeutic benefit. Future clinical trials should investigate therapeutic benefits of low dose CBD.

Table 1.

Sociodemographic characteristics by past year HTC use

	Total (n=878)	No PY HTC (n=410)	PY HTC (n=468)	p-value
Sex				0.44
Female	95.0%	95.6%	94.4%	
Male	4.1%	3.9%	4.3%	
Gender non-conforming	0.9%	0.5%	1.3%	
Age				
Mean (SD)	55.5 (12.2)	56.9 (11.4)	54.2 (12.7)	0.0004
Annual Household Income (US$)				
Less than $50,000	39.4%	36.1%	42.3%	0.08
$50,001-$99,999	31.8%	31.0%	32.5%	
$100,000+	22.0%	24.9%	19.4%	
Missing	6.8%	8.0%	5.8%	
Education				0.21
High school degree, GED, or less	10.7%	8.8%	12.4%	
Associates degree or some college	43.6%	42.7%	44.4%	
Bachelor's degree (BA, BS, AB, BBA)	24.6%	26.1%	23.3%	
Masters, Professional or Doctoral degree	20.6%	22.2%	19.2%	
Missing	0.5%	0.2%	0.6%	
Employment Status				0.05
Unemployed (currently looking for work)	2.1%	1.7%	2.4%	
Student	0.7%	1.2%	0.2%	
Employed full time (40+ hours per week)	19.7%	20.5%	19.0%	
Employed part time (less than 40 hours per week)	7.7%	6.3%	9.0%	
Unemployed (not currently looking for work)	3.8%	3.7%	3.9%	
Retired	30.0%	31.7%	28.4%	
Self-employed	5.2%	7.1%	3.6%	
Unable to work	30.8%	27.6%	33.6%	
Missing	0.1%	0.2%	0.0%	
Relationship Status				0.08
Single (never married)	8.7%	6.6%	10.5%	
Married	62.4%	64.4%	60.7%	
In a domestic partnership	6.3%	5.6%	6.8%	
Divorced	17.2%	16.6%	17.7%	
Widowed	5.1%	6.6%	3.8%	
Missing	0.3%	0.2%	0.4%	
Race/Ethnicity				0.81

	Total (n=878)	No PY HTC (n=410)	PY HTC (n=468)	p-value
American Indian/Alaska Native	2.3%	2.0%	2.6%	
Asian	1.4%	1.5%	1.3%	
Black or African American	2.8%	2.2%	3.4%	
Hispanic or Latino	5.6%	5.1%	6.0%	
Native Hawaiian/Other Pacific Islander	0.3%	0.2%	0.4%	
White/Caucasian	89.9%	92.0%	88.0%	
Other	1.8%	1.5%	2.1%	
Missing	0.5%	0.5%	0.4%	
Legal cannabis				<0.001
Yes	75.1%	67.2%	82.6%	
None	24.9%	32.8%	17.4%	
CMSI				0.004
Mean (SD)	21.1 (7.8)	20.3 (7.5)	21.9 (8.1)	
FM Score				<0.001
Mean (SD)	18.7 (5.7)	18.0 (5.5)	19.3 (5.7)	

Participants using HTC in the past year were younger and had a higher burden of pain symptoms than those who did not use HTC in the past year.

Table 2.

CBD decision making behaviors

	Total (n=878)	No PY HTC (n=410)	PY HTC (n=468)	p-value
Where do you purchase CBD?				
Online vendor	44.2%	52.7%	36.8%	<0.001
Medical cannabis dispensary	29.8%	12.9%	44.7%	<0.001
Brick and mortar retailer (e.g., supermarket, gas station, etc…)	15.5%	20.7%	10.9%	<0.001
Other	8.3%	11.5%	5.6%	0.002
Adult use cannabis dispensary	13.6%	7.1%	19.2%	<0.001
A friend or acquaintance	11.5%	8.0%	14.5%	<0.001
I grow my own	2.4%	0.0%	4.5%	N/A
Doctor's office	3.6%	5.9%	1.7%	0.001
How do you select which CBD product to purchase? Please select all that apply.				
Personal research	63.2%	62.0%	64.3%	0.47
Advice from employee at place of purchase	36.2%	27.3%	44.0%	<0.001
Customer reviews	22.7%	22.2%	23.1%	0.76
Potency	27.8%	23.9%	31.2%	0.02
Brand recognition	16.6%	17.6%	15.8%	0.49
Independent, third-party testing	18.8%	21.2%	16.7%	0.08
Endorsement by a friend	25.5%	28.3%	23.1%	0.08
Endorsement from a medical professional	16.4%	17.1%	15.8%	0.61
Advertising	4.6%	5.9%	3.4%	0.08

Respondents using HTC (high THC cannabis) in the past year purchased products at dispensaries far more frequently than those who did not use HTC in the past year.

Table 3.

CBD product use behaviors

	Total n=878	No PY HTC (n=410)	PY HTC (n=468)	p-value
CBD product administration routes				
Smoking	13.0%	1.5%	23.1%	<0.001
Vaporizing CBD-dominant flower	6.5%	2.2%	10.3%	<0.001
Vaporizing CBD concentrates	12.8%	4.9%	19.7%	<0.001
Eating	33.5%	20.2%	45.1%	<0.001
Topical application	48.9%	44.9%	52.4%	0.02
Tinctures	64.8%	65.6%	64.1%	0.71
Other	9.8%	12.4%	7.5%	0.01
Missing	0.2%	0.0%	0.4%	N/A
Number of administration routes used				
Mean (SD)	1.1	0.8	1.2	<0.001
Administration routes				
Non-inhalation only	75.3%	92.9%	59.8%	<0.001
Inhalation only	3.8%	1.7%	5.6%	
Non-inhalation+inhalation	20.7%	5.4%	34.2%	
Missing	0.2%	0.0%	0.4%	
CBD Preference				<0.001
CBD isolate (solely CBD)	26.8%	38.0%	16.9%	
Full spectrum CBD <0.3% THC	41.8%	44.6%	39.3%	
CBD with >0.3% THC	20.5%	4.6%	34.4%	
No preference	10.9%	12.7%	9.4%	
CBD product use: Days per week				0.98
1	6.6%	7.1%	6.2%	
2	5.8%	5.4%	6.2%	
3	9.5%	9.0%	9.8%	
4	9.2%	9.3%	9.2%	
5	9.6%	9.3%	9.8%	
6	5.1%	4.9%	5.3%	
7	53.8%	54.9%	52.8%	
Missing	0.5%	0.2%	0.6%	
CBD product use: Times per day				<0.001
Once	40.4%	46.8%	34.8%	
Twice	37.6%	39.0%	36.3%	
Three times	12.9%	9.0%	16.2%	
Four times	4.8%	3.2%	6.2%	
Five or more times	4.2%	1.9%	6.2%	
Missing	0.1%	0.0%	0.2%	

	Total n=878	No PY HTC (n=410)	PY HTC (n=468)	p-value
Stable dosing pattern				0.03
Yes	66.6%	70.5%	63.2%	
No	33.0%	29.3%	36.3%	
Missing	0.3%	0.2%	0.4%	
Time till stable dosing pattern established				0.01
Less than one month	39.7%	46.7%	35.5%	
1-6 months	39.0%	36.3%	37.5%	
>6 months	8.3%	5.9%	11.1%	
Missing	13.1%	11.1%	15.9%	

People who used HTC (high THC cannabis) in the past year used less CBD isolate products and reported far higher use of inhalation administration routes as well as more uses of CBD products per day. Continuous data differences measured via t-test. Categorical differences measured via Chi-square tests.

Table 4.

CBD product dosing and administration in the study population

	Days per week Mean (SD)	Times/day: Mean (SD)	Known dose per session: Mean (SD)	Known dose per day: Mean (SD)	Unknown doses: n (%)
Smoking	5.0 (2.3), n = 109	2.9 (2.4), n = 106	4.2 (1.9, n = 100	10.4 (9.5, n = 100	N/A
Vaping flower	4.3 (2.3) n = 50	2.3 (1.7) n = 44	3.8 (1.8) n = 46	10.1 (10.5), n = 41	N/A
Vaping concentrates	4.3 (2.3) n = 104	2.9 (2.2) n = 101	3.2 (1.8) n = 105	8.4 (9.7) n = 105	N/A
Edibles	4 (2.4) n = 284	1.5 (0.9) n = 285	15.9 (11.7), n = 152	24.2 (26.6) n = 152	n = 97 (34%)
Topicals	4.4 (2.2) n = 423	1.9 (1.1) n = 422	N/A	N/A	N/A
Tinctures	5.1 (2.3 n = 553	1.6 (0.9) n = 552	16.3 (15.7) n = 285	26.6 (31.2) n = 285	n = 193 (35%)
Other	5.6 (2.2) n = 80	1.8 (1.4) n = 80	N/A	N/A	N/A

All values reported as Mean (SD). Dose for smoking and vaping is reported in puffs. Dose for edibles and tinctures is reported in milligrams. Dosing values reported do not include unknowns. Notes: 33 (11.5%) participants reported edible doses of >50mg/session and 76 (13.8%) participants reported using tincture doses of >50mg/session. 97 (34%) participants reported not knowing their edible dose, and 193 participants (35%) reported not knowing their tincture dose.